2016-01-01

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http://hdl.handle.net/10026.1/12564

Proceedings of the 32nd Annual ARCOM Conference, ARCOM 2016

IMPROVING THE QUALITY MANAGEMENT SYSTEMS FOR ENERGY-EFFICIENT SOCIAL HOUSING PROJECTS

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Developing and implementing quality management systems (QMS) in construction is particularly difficult because of a lack of standardization, the use of transient workforce and the many parties involved. This paper discusses the challenges faced by social housing providers in the UK when implementing quality assurance programs in their effort to provide their tenants with energy-efficient dwellings. In particular, it focuses on the quality plans defined at the early stages of a project, their impact during the construction process and on the resulting building energy performance. Based on data collected from the project team and documentation, a comparative analysis of the QMS development process of two social housing developments is presented. The key findings show that the two case studies followed different quality management approaches to deliver energy efficient dwellings. The most significant discrepancies were found in defining the energy performance targets and detailing the quality assurance procedures. The contribution of this paper is to create awareness of the importance of defining Quality Assurance Systems with a focus on energy performance from the early stages of a project.

Keywords: Building energy performance, defects, quality management, social housing.

INTRODUCTION

Buildings are acknowledged to play a large role in the current energy use worldwide, being responsible for 40% of primary energy consumption and thus for 40% of the total amount of greenhouse gas emissions (International Energy Agency, 2016). In this regard, the UK government has committed to a legally binding target of reducing carbon emissions by 80% of 1990 levels by 2050 (Her Majesty Government, 2008).

In 2014, the domestic sector in the UK accounted for approximately 26.5% of final energy consumption (Department for Energy and Climate Change, 2015a), 66% of this energy was used for space heating (DECC, 2015b). Therefore, to achieve the carbon emission targets it is pivotal to reduce the heating energy use in the sector by upgrading the thermal performance of the existing housing stock and building new energy-efficient dwellings. In line with the objectives undertaken in the Climate Change Act 2008 (HM Government, 2008), the UK social housing sector has engaged in the recent years in a large scale effort in order to reduce carbon emissions, mitigate fuel poverty and increase the comfort level for their tenants (National Energy Foundation, 2016).

João Alencastro, Alba Fuertes and Pieter de Wilde (2016) IMPROVING THE QUALITY MANAGEMENT SYSTEMS FOR ENERGY-EFFICIENT SOCIAL HOUSING PROJECTS *In:* Chan, P W and Neilson, C J (Eds) *Procs 32nd Annual ARCOM Conference,* 5-7 September 2016, Manchester, UK, Association of Researchers in Construction Management, 1-7.

However, recent studies indicate that the energy savings intended from the energy efficient retrofits and new-built homes are falling short. The social housing providers recognize themselves lacking a clear understanding of the best practices which would lead them to achieving the energy performance targets (NEF, 2016). This mismatch between the energy performance as predicted at design stage and as measured once the building is in operation is known as the performance gap (Hansford, 2015, Zero Carbon Hub, 2014). Among a wide number of contributing factors to the energy performance gap (De Wilde, 2014), poor quality management and the occurrence of defects have been acknowledged. Defects in buildings' fabric, most of them being hidden defects, lead to undesired air permeability and thermal bridging, and consequently to excessive heat loss (Johnston et al., 2015, Bell et al., 2005). According to Zero Carbon Hub (2014), the construction industry has already many quality assurance procedures in place, however they prioritise other issues above energy performance. In that sense, there is need for an increased focus on quality throughout the project which ensures the desired energy performance targets.

This paper seeks to investigate (1) how the social housing providers define and implement quality management systems in their new-built and retrofit projects, and (2) identify areas of improvement in these practices towards achieving higher building energy performance. It particularly focuses on how social housing providers consider building energy performance in the initial definition of requirements of the quality management plan, how these requirements are reflected in the procurement stage and finally, how the initial client aspirations are translated into quality assurance procedures when they are deemed ready for implementation in the construction process. Considering the efforts placed by housing associations (HA) to provide energy efficient housing to help their tenants to reduce energy bills and improve comfort levels, this research particularly focuses on the social housing sector.

QUALITY MANAGEMENT IN CONSTRUCTION PROJECTS

The implementation of a quality management system (QMS) in construction organisations has received considerable attention in the last two decades. However, there is a growing body of evidence that shows the existence of repetitive quality issues due to recurrent causes which undermines project goals, including the energy performance (Tofield, 2012). For instance, according to 2015 UK Construction KPI Annual Report (Davis et al., 2015) around 31% of the projects completed in 2015 in the UK could not meet their original budgets and 60% had schedule overruns. There are many intertwined reasons which lead projects to unexpected outcomes, being quality defects one of them (Tofield, 2012).

The effect of defect occurrences on buildings' energy performance has also been reported in the literature review (Johnston et al., 2015). According to research developed by Carbon Trust (2011) looking at 28 new-build case studies in the UK, the operational energy use was up to five times higher than estimated at the design stage, mainly due to quality issues in the buildings' envelope and services.

The benefits of QMS include: higher customer satisfaction, improved programme and budget performances, improved relationships among the involved parties and reduced defect occurrences which might impact in the energy performance of buildings (McIntyre and Kirschenman, 2000, Tofield, 2012). However, research shows that in order to achieve these benefits, a number of operational issues and barriers need to be addressed prior to the implementation of the quality management plan (McIntyre and Kirschenman, 2000).

The primary barrier reported is the nature of the construction industry itself, which involves projects often complex and large, labour intensive and rarely placed in the same location. In addition, there is no constant or standard output as the demand is always fluctuating and projects vary from client to client, are subject to the client's perception of the quality and value and face cut-throat competition (Sommerville, 2007).

The multitude of professionals and organisations involved in the project, each of them with their own interests, also pose an important challenge to achieve the aspired quality (Kanji and Wong, 1998). According to Tofield (2012), the many participants often do not share the same background in terms of the necessary technical knowledge and management procedures needed to deliver energy efficient buildings. In that sense, project partnering is a method that can be used to promote cooperation and knowledge sharing between the different parties involved in a project. Kanji and Wong (1998) states that: 'Project partnering is a synergy – a cooperative, collaborative management effort among contracting and related parties to complete a project in the most efficient, cost-effective method possible, by setting common goals, keeping lines of communication open and solving problems together when they arise'. Moreover, Hoonakker et al. (2010) state that a successful partnering requires mutual trust among the parties, commitment and discipline. It must be introduced as early as possible in the project in order to allow a proper definition of the project's objectives and strategies, including energy performance targets and QMS focused on energy efficiency of buildings.

Quality is also at risk whenever the design changes are excessive (Hoonakker et al., 2010, Gibb and Isack, 2001). Design changes during the construction phase may occur to adapt the construction details to the construction processes or are variations required by the contractor or the client which were not considered in the project inception or design stages, due to lack of integration among the parties. Although, the majority of the projects are one-offs, the different stages and methods deployed in the construction process have several similarities (Karim et al., 2005). In that sense, the extensive use of processes and procedures must be welcomed by the project team as a powerful tool to enhance quality and achieve the desired energy efficiency (Gibb and Isack, 2001, Zero Carbon Hub, 2014).

In addition to the significant challenges existing in the design and construction phases, the tendering stage has also been identified as a key process to achieve quality standards. The typical tendering process starts with the release of a project requirements and characteristics for a specific group of contractors or a general public, depending on the procurement route and tendering model. The quantity and quality of the details of a project can vary; nevertheless there must be a minimum amount of information in order to allow the contractors to assess the risks involved and to propose strategies to fulfil the predefined goals (Hoonakker et al., 2010) and energy performance objectives. According to Hoonakker et al. (2010) and McIntyre and Kirschenman (2000), the low bids and adversarial contracts poses the greatest concerns of implementing quality programmes. To the authors' knowledge, competitive bidding is still a standard practice and can lead contractors to reduce the allotted resources towards safety and quality assurance procedures or to hire cheaper and less skilled subcontractors in order to maximise the profit margin for the contract.

Some owners and general contractors, however, are already realizing the benefits of using pre-qualification criteria for selecting and granting contracts (Hoonakker et al., 2010). The use of pre-qualification criteria requires the tenderers to meet a pre-set level of performance, experience, safety and implemented quality management system (Loushine et al., 2006). In other words, this approach provides a structured way which allows the owner or general contractor to reduce the risk of working with a poor performing sub-contractor which might compromise the process of delivering energy efficient homes.

METHODOLOGY

The findings presented in this paper are derived from two case studies of a social housing provider located in the South West of the UK. The case study is a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within real life context using multiple sources of evidence with a holistic approach (Yin, 2009).

The social HA partaking in the research owns and manages 14,275 homes within one of the major cities in the South West. As part of their commitment to help the social tenants to reduce their energy bills and increase their comfort, as well as tackling carbon emissions, the association is undertaking a major investment to improve the energy performance of the current stock and the new homes.

The two case studies are: (1) 72 new affordable dwellings built at Passivhaus standard; and (2) retrofit (external wall insulation) of 38 housing units grouped in 4 building blocks. These two diverse projects were selected seeking to identify similarities and differences on the approaches taken with regards to quality management by the HA in each project, despite having a standard corporate quality management system in place.

According to Yin (2009), empirical investigations, in order to avoid biased conclusions, must rely on multiple sources of evidence, with data needing to converge in a triangulating fashion. For that matter, this research is based on data collected from documents (minutes, contracts, tendering packages, quality programmes, etc.), technical information (plans, detail books, etc.), interviews with the project stakeholders (client, project manager, contractor, architect and consultant) and observations during team management and design meetings. This data has been collected from the early stages of the project and will continue until the completion. This paper, however, presents the initial findings of the stages: 1. Inception, 2. Procurement Strategy, 3. Design Outline and 4. Technical design and Construction preparation.

Data is organised following a logical and temporal sequence of the project stages based on a combination of the proposed project management framework from the Office of Government Commerce (2007) and the Royal Institute of British Architects Plan of Work (2013). The analysis of data and the subsequent conclusions are drawn by comparing the case studies' findings against the following theoretical basis: (i) Clearly defined and shared goals and energy performance targets; (ii) Involvement of the parties throughout the process; (iii) Set up of selection criteria (tendering process); (iv) Standardisation; and (v) Set up of quality assurance procedures.

CASE STUDIES

Case Study 1 consists of 72 new affordable dwellings built at Passivhaus standard (Building Research Establishment, 2016). The procurement route is a two-stage Design and Build contract. The client commissioned an independent project manager not only to help with the stages prior to procurement but to work as a facilitator for the whole process. The design team and Passivhaus consultant were novated to the contractor after the procurement stage.

Case Study 2 comprises the retrofit of 38 housing units grouped in 4 building blocks. This project is part of a 20 year retrofit programme, which includes the installation of external wall insulation, funded entirely by the HA. This programme follows an already applied external wall insulation programme which involved 4,009 units. It is expected that the external wall insulation installations will increase the current SAP ratings (BRE, 2013) of the retrofit homes from 71.6 to 81. A traditional procurement is used for this project. Whilst in the previous case study, a specialist design consultant was employed to achieve the desired energy performance standard, the internal design team of the HA was selected to work on the retrofit scheme as they already had experience accumulated from previous refurbishment works. The asset manager was commissioned to play the role of the project manager.

It is worth mentioning that although the two case studies pertain to the same HA, they are coordinated by different managerial branches: Case Study 1, led by the new asset development branch; Case Study 2, led by the asset management branch.

KEY FINDINGS

Case Study 1: 72 new affordable dwellings built at Passivhaus standard

At the project inception stage, the HA’s team decided to build the new dwellings at Passivhaus standard. An experienced Passivhaus consultant was employed early in the process to assist not only the already appointed design team but also the independent project manager.

The procurement route chosen was design and build. Since the awarded tenderer would be expected to deliver the Passivhaus requirements, it was found important to involve the contractor in early stages of the project and make them responsible for the design process. However, the design team and the specialist consultant were novated to the contractor in the following stages.

The tendering was a two-stage process. The tendering information pack included: a clear set up of performance requirements (e.g. heating demand and airtightness); the Passivhaus accreditation process explained; the performance checks to undertake during the construction process (e.g. airtightness tests); and a list of minimum performance specifications for products and equipment in order to comply with the Passivhaus standards. The invited tenderers were asked to submit their tender, which should include their price for delivering the project along with proposals for how the client’s requirements would be satisfied. These proposals should contain the intended strategies to achieve the Passivhaus accreditation, to accomplish the design requirements, to manage the subcontractors and assess their performance and skills, and assure quality and rectify eventual defects.

The design process was supported by the Passivhaus Planning Package, which helped the design team and the main contractor to develop a design proposal that would respond effectively to the defined budget and schedule, as well as comply with the energy performance targets. In this stage several technical solutions were assessed and discussed by the different parties involved in meetings arranged every two weeks. In several occasions bespoken design solutions were adopted. Unfolding the quality assurance strategies proposed at the procurement stage, the main contractor commissioned a dedicated quality surveyor who helped defining and implementing the quality assurance procedures in the next stages of the project. It was also acknowledged that both the quality surveyor and the site manager would benefit from having Passivhaus training, in order to become more acquainted with the requirements and steps of the accreditation process.

During the technical design and construction preparation phase, the quality programme was consolidated prior to the completion of the technical design and detailing. The quality plan was structured in three parts. The first section was conceived to re-enforce the quality of the technical design, assessing the buildability of the details and the sequencing of the building elements. The second section consisted in identifying the milestones for checking the quality of selected building elements and determining the testing procedures. For instance, it was decided that the pressure tests during the construction process should be performed after the air barrier was installed but prior to the external cladding execution. The third section was aimed at producing the necessary tools to support the quality assurance procedures, such as checking lists and defect record sheets. In order to validate the established quality assurance plan and find areas of improvement, the parties agreed on testing the methods in a set of 5 homes. Therefore, the construction programme was defined so as to allow the construction of 5 dwellings whilst the earthworks and infra-structure execution is being undertaken on-site and before the construction of the rest of the 67 housing units starts.

Case Study 2: External wall insulation in 38 dwellings grouped in 4 building blocks

At the inception stage of the project, the HA asset management team declared their performance aspiration (i.e. increase the current SAP ratings from 71.6 to 81). Despite the HA having such a specific goal, there was no evidence in the project documentation of the specific performance targets (e.g. u-values and air permeability) that the retrofit scheme was aiming to meet. Moreover, the project documentation also lacked of the condition surveys of the dwellings to be retrofitted. A list of practical recommendations was developed by the asset management team based on the previous similar retrofit schemes, such as the retrofit works of the ECO schemes. This recommendation list became the basis for the definition of the technical requirements for both the tendering information packages and design stage.

The procurement approach chosen for the retrofit scheme was the traditional route, where both the design and the project management team pertained to the HA staff and a main contractor is responsible for the construction phase only. The traditional route allowed carrying out the procurement and design outline stages in parallel. However, it limited the amount of involvement of the future contractor in the design process.

The tendering information packages, i.e. the invitation to tender documents and contracts, included a pre-defined technical solution for the external wall insulation. The asset management team defined the retrofit solution and its technical characteristics (mostly addressing to thermal bridging) based on previous experiences, where this technology had been deployed in previous works with apparent success and cost effectiveness.

In regard to the quality assurance plan, the HA administered the set of procedures which are standard to similar projects they are undertaking. The pre-selection criteria specified that the tenderers must maintain a recognised "quality assurance system" such as ISO 9001 certification. Apart from that, the HA did not require performance tests or specific checking points to be undertaken during the construction phase, as no performance targets were defined in the early stages of the process. In fact, the HA's standard quality plan is focused on preventing visual defects which are likely to raise occupants' complaints but do not specifically concentrate attention in quality defects related to thermal issues. The main contractor is required to provide the HA's representatives with quality reports once the work for each housing unit is deemed completed. In addition, the contractor must submit all the material invoices to the project manager as a way to prove that the products deployed comply with the design specifications.

During the construction preparation stage, the project manager manifested that additional efforts (on both the design and construction aspects) would be put in place in order to increase the chances of the project to fulfil its aspirational objectives. The measures adopted to improve the design aspects included the appointment of an experienced energy performance consultant to assess the air permeability of the units, undertaking airtightness tests before and after the retrofit in a sample of 20% of the dwellings. Moreover, the consultant assessed the condition of cavity closers and the eaves/wall junctions. As a consequence, the technical detailing produced by the HA's design team was checked and revised. The measures adopted to improve the construction aspects included the appointment of a group of building surveyors working on behalf of the HA in order to check on the quality of the workmanship in parallel to the quality assurance procedures already required to the contractor.

DISCUSSION

Clearly defined and shared goals and energy performance targets

In Case Study 1, since the decision to comply with Passivhaus standards was made, the HA stakeholders acknowledged that external support would be needed throughout the process. Being this the first Passivhaus project in the company, it urged for a different mind-set which allowed the construction of an environment of collaboration and cooperation towards shared goals, as suggested by Hoonakker et al. (2010). In line with what was stated by McIntyre and Kirschenman (2000), a multidisciplinary team was hired to work together from the early stages of the project, providing a clear performance targets and strategies which laid the pavement for the procurement stage and the development of the quality assurance plan later in the process. Moreover, the procurement route allowed the contractor to join in the project on time to collaborate from the beginning of the design stage.

Differently in Case Study 2, the asset management branch had a strong background of housing maintenance and refurbishment accumulated in previous works. In fact, the option of using the *traditional* approach in the procurement process was intended to allow the project to fully benefit from the acquired knowledge on similar projects, assuring that the design and project management would be undertaken by the company's staff, and keeping the control of the process within the company. This procurement approach was meant to re-enforce the deployment of standardised technical solution and procedures (Gibb and Isack, 2001), nevertheless it did not take into account the valuable contributions of the awarded contractor as recommended by Kanji and Wong (1998), keeping it apart from the initial stages of the process. Besides, to the authors understanding, the whole process lacked of guidelines of what was expected for the real energy performance. It was assumed that the set performance goals would play this role. As a matter of fact, the aspirational goals of increasing the SAP ratings did not work as proper drivers to the process because they only provided standardised estimates of energy performance and consumption, instead of real performance targets that could be measured during the construction process and in the operational stage; and later on could be compared to the energy performance of the buildings prior to the retrofit works.

Involvement of the parties throughout the process and Management commitment

In terms of creating a required environment for the developing management commitment and trust between the different parties, the Case Study 1 adopted a strategy of full involvement of all parties' stakeholders throughout the design development and construction preparation in order to deliver appropriate technical solution and managerial procedures towards achieving the proposed energy performance goals (Hoonakker et al., 2010). Meetings for the development of the design and technical solutions were arranged in every fortnight until the end of the stage 4 – Technical design and construction preparation. The main idea, also shared by Kanji and Wong (1998), was that the options should be discussed and the decisions shared among multidisciplinary project team, always driven by the clear objectives, including energy performance targets, to be achieved. On the other hand, in Case Study 2 the different stages of the process were fragmented not allowing too much room for collaboration or discussion about the best ways to achieve the desired energy efficiency, just as described by Sommerville (2007). For instance, the fact that the project manager requires the contractor to submit the material invoices during the construction stage so he can check whether the purchased products comply with the design specification indicates evidences of mistrust, lack of managerial commitment and shared objectives towards the outcome of the project, already stated by Loushine et al., (2006). Another example was the fact that the project manager commissioned an energy specialist consultant to check and revise the design team's detailing regarded the energy efficiency. It would be more adequate to allow the consultant to contribute in a cooperative way in the beginning of the design stage, incentivising teamwork.

Standardisation and Set up of quality assurance procedures

Regarding the development of the quality assurance plan, in Case Study 1 the project manager on behalf of the HA made clear from the procurement stage that a bespoken quality assurance procedures would be necessary in order to accomplish the energy performance targets. In fact, the developed plan started to drive the quality process yet in the last stages of the design process and after that setting the testing and checking procedures for the construction stage. In respect to Case Study 2, the inclination to use standardised set of procedures based on previous experiences proved to provide consistent contributions in terms of the expertise accumulated (Karim et al., 2005). Nevertheless, in respect to the issues related to the energy performance, the standard quality assurance plan would not add much value because it was not designed to this purpose. Even though the additional effort put in place in order make the detailing more robust seems to be mistimed and uncoordinated, it will definitely contribute to increase the buildings' operational energy performance. Moreover, the group of building surveyors commissioned to check the quality during the construction stage would be more effective if the quality assurance plan would have been reviewed, setting structured checking procedures and milestones for inspections and not only relying solely on the accumulated knowledge, as suggested by Tofield (2012).

CONCLUSIONS

To the authors understanding, it is undeniable that the parties involved in both case studies acknowledged that pursuing quality during the construction process is paramount to achieve the desired energy performance targets. However, the cases undertaken in this research differ in how to set out the proper strategies which allow the development of an effective quality assurance plan.

The first key factor in order to produce a quality assurance plan which encompasses measures that help achieving the desired energy performance is to have a robust understanding of the performance targets to be defined. It is also crucial to understand the issues which might undermine the achievement of the targets in terms of faulty design and detailing, as well as quality defects that may occur in the construction stage. In that matter, having experienced professionals among the parties involved from the beginning of the project is vital. Moreover, the performance targets must be measurable, ideally during the construction process, so any necessary corrections can be applied early enough and when the remediation costs are less expensive than the operational stage. In regard to retrofit schemes, a full assessment of the building condition is fundamental to understand the challenges that might be encountered ahead and select the most suitable strategies.

The second key factor is choosing the proper procurement route which would suit the project's characteristics and aspirations. The procurement approach should allow the different parties to get involved early in the process in order to develop a shared decision-making environment and thus, generate commitment between the parties. In terms of the procurement information packages, it must provide the tenderers with sufficient information on the desired performance targets and how the tests and evidences of the performance levels are to be provided. Additionally, the awarded contractor should be legally bound to fulfil the performance targets through the contract documentation. The contractual clauses should have to go hand in hand with a measurement mechanism which must be supported by the quality assurance procedures to be implemented during the construction phase.

The overall idea is that the process of developing a quality assurance plan must start with a clear definition of the performance targets in the early stages of the process. The second step is to identify the adequate strategies which would guarantee that the targets will permeate the following stages from the procurement to the design and construction preparation phase, culminating in the completion of the quality plan. The strategies to be implemented should be able to translate properly the performance goals into objective and accountable measures. These measures, in turn, will stablish responsibilities, milestones for checking and testing and adequate ways to report the performance of the building elements surveyed. Nevertheless, a robust quality programme is not made only of a set of procedures and tools; to be effective it requires an environment of trust, collaboration and team working.

ACKNOWLEDGEMENTS

The research reported in this paper is being undertaken as part of a PhD research project at Plymouth University. The project is funded by the Brazilian Ministry of Science, Technology and Innovation through the Science without Borders research program (Project reference: 203105/2014-1).

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